ESSAYS IN SCIENCE

By

PARTICIPANTS IN
THE SCIENCE TALENT SEARCH
CONTEST
1963

DEPARTMENT OF SCIENCE EDUCATION
NATIONAL COUNCIL OF EDUCATIONAL
RESEARCH AND TRAINING

Essays in Science

(Written at the Examination)

By the
Participants of
The Science Talent Search
Contest, 1963

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Foreword

The Science Talent Search Examination was held for the first time in Delhi Territory in 1963. The contest was open to students of Higher Secondary and Senior Cambridge Schools. Over three hundred and fifty students entered the contest. The students were required to write an essay on one of the scientific topics set for the examination.

This publication brings together nine essays selected from those contributed by the contestants at the time of examination. They cover a wide and interesting range of ideas and will be of particular interest to those who are concerned with education for the promise of talent that they disclose.

The scientists and creative thinkers of the future are in our schools today. It is without doubt one of the primary responsibilities of the school to recognize this talent and, with care, to foster its growth.

This small publication is offered in the hope that while serving as encouragement to other students it will also draw the attention of our schools to the vital need of providing for our talented pupils programmes which offer a challenge to their ability.

RAJA ROY SINGH
Joint Director
National Council of Educational
Research and Training

New Delhi
October 4, 1963

Some Basic Facts

R. N. Rai
Head of the Department
of Science Education

The Department of Science Education, National Council of Educational Research and Training, implemented a pilot project of Science Talent Search Scheme during 1963. The main procedures of selection consisted of :

A science aptitude test —165 marks
An essay paper — 50 marks
Interview — 75 marks
Academic Achievement — 10 marks

The science aptitude test had 165 questions of the factual and thought type, with answers on the multiple choice pattern. It covered items on fourteen different branches of science.

The essay paper offered four topics—Vitamins, Organic Evolution, Atoms and Molecules and Chemistry in the Service of man. The candidates were required to write an essay on any one of these four topics, in not more than 3,000 words. With each topic, some broad headlines were also given on the basis of which the student could develop the essay.

An analysis of the essay scripts indicates a remarkable feature: out of a total of 367 candidates who appeared at the essay examination, 204 wrote on 'Atoms and Molecules', 120 on 'Chemistry in the Service of Man', 38 on 'Organic Evolution' and five on 'Vitamins'.

The largest number chose the essay on 'Atoms and Molecules', probably because this particular topic is comprehensively dealt with in the chemistry and physics syllabi. Also, considerable literature is readily available on the subject in the school libraries. The least number of students wrote on 'Vitamins'. The reason for this is obvious—this subject does not form a regular part of the routine science curriculum and very little literature is easily available to the students. 'Chemistry in the Service of Man' was well attempted, while 'Organic Evolution' had a poor response. This may have been due to the fact that this topic is of interest only to biology students, whose number is comparatively very small.

The frequency distributions of scores of the four essays indicate almost normal distribution for 'Atoms and Molecules' (average score 26), and 'Chemistry in the Service of Man' (average score 24·5), while that for 'Organic Evolution' is slightly negatively skewed (average score 25). In the case of 'Vitamins', it is not possible to infer about the nature of distribution of scores because the total number is too small (average score 14.5).

It is interesting to note that the percentage of students scoring marks above 30 (maximum score 50) in the four essays was again in a descending order as shown below:

Atoms and Molecules	29%
Chemistry in the Service of Man	27%
Organic Evolution	25%
Vitamins	0%

It is, however, very encouraging to observe that there is a growing tendency in the talented students to read widely on scientific topics outside their routine curriculum. This is brought out by the performance on the second and third topics. The last topic has been ignored presumably because it is not so fascinating and is slightly off the track of a talented student, who is primarily interested in the marvels of the active sciences.

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Atoms and Molecules

ESSAY 1

Arun Kumar Sanwalka
Ramjas Higher Secondary School
New Delhi

Every thing in this world is made up of atoms, a very very small particle. 'Every thing in this world is made up of atoms' the statement may seem to be an exaggeration to a layman but it is not. The desk on which I am writing, the pen, the paper, the clothes, the buildings, the compounds, the elements, the earth, the sun, and even man himself is made up of atoms. And about its size, it is so small that even the best microscopes have failed to magnify it so as to enable the human eye to view it. There are more atoms in a glass of water than there are grains of sands on all the banks of all the oceans in the world. There are more of them in a glass of water than there are glasses of water in all the seas of the world. Fantastic ! Isn't it, but, yet, absolutely true.

Since long, scientists have been researching upon this atom. John Dalton, a school teacher, was the first to give a living hypothesis about the atoms, known as Dalton's Atomic Theory. It stated :

1. Atom is the smallest particle of an element which retains its individuality in a chemical reaction and cannot be broken any further.

2. Atoms of the same element have similar properties and similar weights.

3. Atoms of different elements have different properties and different weights.

4. Atoms of different elements combine in a fixed and simple ratio to form compound atoms.

5. Atoms can neither be created nor destroyed.

This was the first theory about atoms. Well, the theory has now undergone drastic changes at the hands of modern scientists. Due to the recent researches, the theory has been changed a lot and is now as follows—

1. Atom is no longer an indivisible particle but can be divided further though it is yet the smallest particle retaining its individuality in a chemical reaction.

2. Atoms of the same element may have different weights.

3. Atoms of different elements may have the same weight.

4. Atoms of different elements combine together in a fixed and integral ratio to form molecules.

5. Atoms cannot be created but some of them can at least be altered.

Modern scientists have proved that atoms can further be subdivided into particles still smaller. The main particles are—protons, electrons and neutrons. Rutherford was the first man who succeeded in splitting the atom and finding the particles.

Atom has a very complex structure. It consists of mainly two parts : the *nucleus*, i.e., the inner part, and the outer portion.

Nucleus is the centre of the atom and is about 1/10,000 in diameter of the atom itself. It is surely difficult even to imagine such a small particle and it is still more wonderful that the whole weight of an atom (however little it may be) is contained in this very nucleus.

The nucleus consists of particles called *protons* and *neutrons*: Only these two types of particles are in the nucleus. Protons are the particles having a mass equal to that of a hydrogen atom and are positively charged. The neutrons also possess nearly the same mass as protons but these are electrically neutral.

The rest of the space in atoms is all occupied by electrons. The electrons are the particles which are negatively charged and have mass equal to 1/1847 of a proton. So the mass of an electron is more or less negligible. The electrons outside the nucleus are not put together as are the protons and neutrons in the nucleus but are arranged in orbits just as the planets revolve round the sun in different orbits. This concept of an atom was made by Niels Bohr, an eminent scientist. The need for the explanalion came from the fact that positive and negative charges attract each other. Now protons being positively charged and electrons being negatively charged should attract each other so that the electrons should come into the nucleus. But this would have upset the whole concept. Niels Bohr gave a plausible reasoning. He compared the nucleus to the sun and the electrons to the planets revolving round in orbits around the nucleus. The energy[1] needed for the motion of electrons in the orbits at tremendous speeds is supplied by the force of attraction between the protons and electrons.

The electrons are present in the orbits according to some well formulated laws :

1. The number of electrons present in any orbit cannot be greater than $2 \times n^2$ where n is the number of the orbit so that if $n=2$, i.e., in the second orbit the maximum number of electrons can be $2 \times 2^2 = 8$. Similarly, in the third there can be at the most 18 electrons, and so on.

2. The last orbit cannot have more than eight electrons and the last but one not more than 18 electrons.

An atom is electrically neutral though it contains particles having positive and negative charges ; so evidently the conclusion is that the number of electrons in an atom = the number of protons.

The atomic weight of an atom is the average relative weight of its one atom as compared to that of oxygen. The weight of an atom is due to the protons and neutrons only, the electron being 1/1847 in weight of a proton. This can be easily demonstrated from the following experiments.[2]

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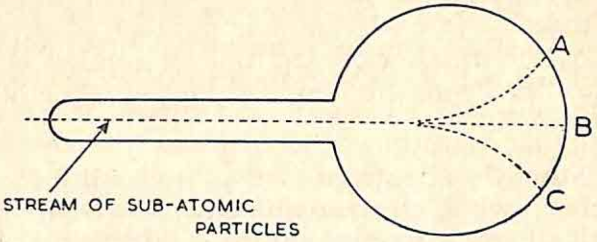
[1] The electrons in the atom do not need any energy to move them. The force of attraction due to the nucleus keeps them moving in their orbits. —*Ed.*

[2] This experiment as conceived is not a practical one. —*Ed.*

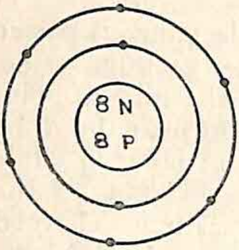


A stream of protons and electrons is passed through a tube having complete vacuum inside. Let it strike the circular end of the tube at point B. Now if a magnet be brought near the tube we see that the protons strike at point C while electrons strike at A. This is evident as the magnetic field deflects the oppositely charged particle in the opposite direction but the displacement in the positions of the two is the thing with which we are concerned here. The displacement of electrons is relatively very large as compared to that in protons and from here we can easily compare their weights.

The number of electrons or protons present in an atom is known as its atomic number which is the fundamental property of elements. There are about 102 elements known and every element has been assigned a number from 1 to 102, the first element being hydrogen.

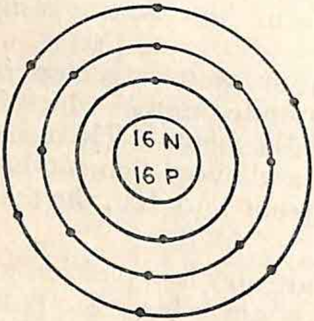
Knowing all these we are now in a position to draw some atomic structures ourselves. Suppose it is required to draw the structure of oxygen which has atomic weight = 16 and atomic number = 8. Now atomic weight is equal to the weight of protons and weight of neutrons but each of these particles weigh unity in the atomic balance, so that, weight of protons = number of protons, and weight of neutrons = number of neutrons, and so atomic weight = number of protons+number of neutrons. Now the atomic number of oxygen is 8, i.e., the number of electrons = number of protons=8. From the above we get number of neutrons = 8.

Now the neutrons and protons all lie in the nucleus while electrons lie outside. So diagrammatically we can represent the structure as follows :



N = Neutrons
P = Protons
The particles in orbit are electrons.

Similarly, the structure of sulphur can be represented as follows :



Atomic weight = 32
Atomic number = 16

It is found that in certain cases the atoms of the same element have got different weights. They are known as isotopes. The isotope elements have the same atomic number but different atomic weights, e.g., chlorine has two types of atoms, one weighing 35 and the other 37 combined together in the ratio of 3 : 1 so that the average relative weight of chlorine atom comes to be 25.5. Now isotopes have the same atomic number, i.e., the number of electrons and protons is the same, so it is only the number of neutrons which causes the difference. Similarly hydrogen has two isotopes having atomic weights 2 and 3. The one having two as atomic weight is known as *Deuterium.* The water formed by the combination of this hydrogen and oxygen is called heavy water used in atomic reactors.

Still there are some other atoms which are of different elements but have the same atomic weight ; e.g., calcium and argon both have atomic weight 40 though their atomic numbers are different and the two are entirely different elements. Such elements are known as isobars.

Atoms of different elements combine together in fixed ratios to form molecules. Before going into the details of molecule we must know why atoms combine.

Atoms on the basis of their atomic structure, can be divided into two categories. One group of atoms contains 8 electrons in their outermost orbit. Now, according to the rule of distribution of electrons, the maximum number of electrons in the outermost orbits can be 8, so these outermost orbits are saturated. Such elements are inert elements and do not enter into any chemical reactions at all. These elements are Helium, Neon, Argon, Krypton, Xenon, Radon.

The rest of the elements have all less than eight electrons in their outermost orbit. So Lewis and Langmuir stated that all the elements have a natural tendency to enter into a chemical reaction so as to obtain the stable configuration, i.e., eight electrons in their outermost orbit. So we can say that elements combine together for this very purpose, e.g., when sodium and chlorine react together, chlorine has seven electrons and so needs one to complete its octet while sodium has one and by giving it, it will have its octet complete. So when these two combine the lending and borrowing of electrons takes place and a new compound NaCl (sodium chloride) is formed.

The new compound is sodium chloride. This sodium chloride does not exist as atoms but in the form of molecules. Molecules are the smallest particles that retain the properties of a compound. The smallest particle of sodium chloride is the molecule of sodium chloride which when split will yield a number of sodium atoms and chlorine atoms but the properties of sodium or chlorine atoms are quite different from those of sodium chloride.

The molecules of a compound can be very very complex, specially those coming in organic chemistry. The molecule is a group of atoms and these atoms are arranged in a molecule in a definite arrangement but if this arrangement is altered, a new compound is formed and this process is called *isomerisation*. This process is possible only in organic chemistry. As an example, C_2H_6O formula can stand for two molecules C_2H_5OH of ethyl alcohol and CH_3-O-CH_3 of dimethyl ether. Thus we see how molecules can exist in different forms while this is not possible with atoms.

Molecules also possess weight and this weight known as molecular weight which is defined as the weight of one molecule of a substance as compared to the weight of one atom of oxygen. Obviously the molecular weight of a compound is due to the weight of its constituent atoms, the molecular weight being the sum of the weights of the atoms constituting the molecule.

Lastly we come to nuclear fission, i.e., the breaking up of atoms of a substance. We have an element uranium. Uranium has two isotopes: U_{235} and U_{238}. U_{235} contains 92 protons and 143 neutrons, while U_{238} contains 92 protons and 146 neutrons. U_{235} the less abundant one, is a fissionable element, i.e., it can be broken.

The fission of atoms was first seen by Fermi*. The principle is as follows :

A neutron acting as a bullet strikes the nucleus of a U_{235} atom. The neutron when it strikes breaks the nucleus in two main fractions and about two neutrons, and a very huge quantity of energy. Now the two neutrons so freed, again act as bullets for two more nuclei and release a great amount of energy as well as four neutrons, each of which again strikes nuclei to give 8 neutrons and then 16, 32 and so on in geometric progression so that a chain reaction is set up and the atoms go on splitting giving out very, very huge amounts of energy.

This is the basis of an atomic bomb. The two earliest bombs dropped on Hiroshima and Nagasaki were made of uranium and plutonium respectively. Such a small thing as an atom develops such a huge energy which cannot be developed by any other means.

This energy can be used for peaceful as well as for destructive purposes. The energy supplied by a small amount of atoms is very huge and can save the fuel and coal supply of the world from getting exhausted. The 'Nuclear *Reactors*' are in progress and they use the huge atomic energy for peaceful purposes which is the only source of energy which can last for thousands of years, without getting exhausted even by 0.1%.

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* Fission was first observed by two German scientists Hahn and Strassmann and correctly interpreted by two other Germans, Meitner and Frisch. —*Ed.*

Atoms and Molecules

ESSAY 2

Amitava Sen
St. Columbas' High School
New Delhi

From the earliest times man has always tried to understand the composition of matter. His scientific mind has considered many different theories. Some of these have been rejected. Others remained unchallenged till they had to make way for more plausible explanations. The theory that holds good at present states that matter fundamentally consists of molecules and atoms. This was first suggested by the English chemist Dalton after much painstaking observation and reasoning.

If we imagine matter being sub-divided, then we ought to come to a stage where the subdivisions are so small as to be indivisible any further. These indivisible particles were given the name *atoms*. Later they were proved to be far from indivisible. In fact, at present the atom is known to be composed of several kinds of particles, some of them carrying electrical charges of varying intensity.*

It was first noted that when gases combined chemically, they did so in definite proportions by volume. From this it was supposed that small whole numbers of indivisible units of substances took part in chemical processes. The composition of compounds was also found to be uniformly constant by weight. From these and other observations Dalton stated his famous atomic theory.

Dalton supposed that matter was composed of small indivisible particles called atoms. All atoms of the same element were considered alike (this was ultimately proved erroneus). Atoms of different elements were different from each other and finally small whole members of atoms took part in all chemical reactions. Thus an atom was defined as the smallest indivisible particle of an element that can take part in any chemical change.

However, it was seen that atoms of all elements could not always exist under normal conditions separately. They combined together in small numbers to form particles that could exist separately. These particles are molecules which are therefore defined as the smallest particles of an element or compound that can normally exist separately. Thus the hydrogen and oxygen molecules are diatomic, and molecules of different elements have different atomicities. The supposition of atoms and molecules led to the weight of elements and compounds being calculated relative to the weight of the hydrogen atom as atomic and molecular weights. Later Avogadro enunciated his theory of combining gases. Molecules and volumes of gases were thus connected by the relation established by Avogadro between them and this theory is now commonly used in the composition of gases.

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*The nucleus consists of protons and neutrons. While neutrons carry no charge, all protons carry the same charge.

—*Ed.*

Molecules and atoms are far too small to be studied by even the most powerful electron microscope, the diameter of an atom being of the order of $_{10}{}^{-8}$ cm. However, it has been discovered by various means that in molecules, atoms are arranged in a definite way. A method of X-raying a molecule from different angles was developed and by superimposing the patterns obtained the structures of molecules have been studied. Thus the complicated lattices of molecules of organic compounds are now being studied, and in 1962 two English chemists were awarded the Nobel Prize for finding out the structure of the protein molecules, haemoglobin and myoglobin. Owing to the different ways in which atoms may be arranged in a molecule, compounds having identical composition by weight may have different properties. This phenomenon has been observed and is called *isomerism*.

Later, atoms were found to be divisible. They were supposed by Rutherford to be composed of two sorts of particles—protons and electrons. Protons were positively charged particles with a mass 1847 times that of the negatively charged electrons. Electrons were supposed to revolve in orbits around protons which formed the nucleus. Later Chadwick while bombarding the berryllium atom with alpha particles discovered the neutron—a particle of mass equal to that of the proton and with no electrical charge. At present it is believed that protons and neutrons form the nucleus of atoms with electrons rotating in shells around them. However, many other subatomic particles such as the positron, the neutron, the antiproton and the meson have been discovered.

The hydrogen atom is composed of one proton and one electron. However, a heavy hydrogen atom with a weight equal to twice that of the normal hydrogen atom also exists and is known as *deuterium*. This consits of a nucleus made of a proton as well as a neutron and one electron. This example contradicts Dalton's atomic theory for these two atoms of hydrogen are quite unlike and are known as isotopes of hydrogen. Similar isotopes of oxygen, carbon, uranium, sodium and other elements exist.

Modern neuclear physics started more or less with the discovery of X-rays or Roentgen rays and radioactivity. Roentgen while experimenting with a cathode ray tube covered with black paper observed that a nearby fluorescent screen was glowing. This led to the discovery that certain substances when struck by cathode rays (electron streams) are excited into emitting very high frequency radiation known as X-rays. These rays were shown to be part of the electromagnetic wave spectrum. Owing to their great penetrating power they are used in medicine for the study of bones, in industry for the examination of metal castings for flaws, and in various other fields.

Becquerel while experimenting with a uranium salt discovered that it caused photographic plates to be fogged even before it was bombarded with cathode rays. This led to the discovery of radioactivity. It was discovered that certain heavy elements towards the end of the Periodic Table of elements have very unstable atoms. These atoms disintegrate spontaneously and emit energy in the form of radiation. Radioactive elements like uranium and radium give off three kinds of radiation, namely α-particles, β-particles and γ-rays. Alpha particles consist of the nucleus of helium atoms composed of two protons and two neutrons. β-particles are simply electrons while γ-rays are not charged particles but a highly penetrating form of radiation of a frequency even higher than X-rays. Experiments with radioactive substances are hindered by the fact that γ-rays are extremely dangerous to human beings.

Radioactivity is a spontaneous phenomenon and after a period of time, radioactive matter is completely converted to pure energy. Thus uranium has a half life of 1620 years[1], i.e. in so many years a certain mass of radioactive uranium loses half its mass in the form of energy.[2] Other elements have even shorter half lives and the most newly discovered element, lawrencium (atomic number 103) has a half life of only 8 seconds, thus giving scientists very little time to conduct experiments with it.

The Joliot-Curies were the first to discover artificial radioactivity, and Rutherford first carried out the transmutation of an element, thus fulfilling the dream of the ancient alchemist. By bombarding nitrogen atoms with alpha particles he obtained an isotope of oxygen and hydrogen. Many elements were thus transmuted and Cockroft and Walton won the Nobel Prize for the transmutation of lithium.

In order to bombard atoms, subatomic particles of very high energy are necessary. For this purposes an instrument called the cyclotron was developed. It consists of two hollow D-shaped metal containers placed between the poles of an electromagnet. An alternating voltage is applied to the D's or D-shaped vessels and the particle to be accelerated is generated at the centre. This particle is then accelerated in a spiral and finally deflected out of the D's and on to the target. The most effective particle used for bombardment is the neutron, for having no charge, it is not repelled by charged nuclei of other atoms.

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[1] The half life of uranium is 4.5×10^9 years. —*Ed.*

[2] In the period of half life, half the amount of a radioactive element changes into another element. —*Ed.*

All chemical processes are accompained by much energy liberated in the form of light and heat. Thus the explosion of T.N.T. which is a chemical process, can cause untold damage. But only whole atoms are involved in such processes. It is then possible to imagine how much more energy is released when the nuclei of atoms are split. This led to the development of nuclear fission and chain reaction in the form of the atom bomb and the atomic reactor.

If the atom of an isotope of uranium U_{235} is bombarded by a neutron, it becomes unstable and splits into two atoms of atomic numbers nearly 36 and 56 and simultaneously liberates a great amount of energy. In disintegrating, an atom of U_{235} liberates more neutrons and thus nuclear fission in the form of a chain reaction is set up. This principle is used in the atom bomb and in the atomic reactor.

In the atomic reactor cylinders of uranium U_{238} in aluminium casings are placed in a block of graphite. U_{238} itself is nonfissionable and contains only 0·05%* by weight of the fissionable isotope U_{235}. However, by using uranium of critical size and slowing down the neutrons by the moderator graphite, a chain reaction was first started by the American physicist Fermi and his colleagues at the Chicago University. In order to have controlled reaction, for an explosion is certainly not desirable in a reactor, cadmium rods are used to absorb neutrons and to slow down the process when required. The energy released is in the form of heat which is conducted away and used to run turbines which generate electricity. Owing to the dangers of radiation, lead or concrete shielding must be used in all atomic reactors. In 'breeder' reactors more fuel is produced than is used for the non-fissionable U_{238} is transmuted to a new and fissionable element plutonium which may be used as fuel all over again.

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* The correct amount is 0.7%. —*Ed.*

Still more modern methods used the principle of the heat of the sun—the principle of fusion. Here deuteron nuclei fuse to form nuclei of helium liberating at the same time a vast amount of energy. This principle is used in the hydrogen bomb. However, very high temperatures must be produced before such fusion can take place.

A further step was taken in nuclear physics with the discovery of cosmic rays. These particles, mainly protons, are highly penetrating particles from outer space. Scientists say that they have too much energy to be the result of nuclear fusion, Double stars observed by astronomers probably act as cyclotrons and give to such particles, velocities that are sometimes 1/10th of the velocity of light which cannot, by Einstein's Theory of Relativity, be exceeded. Among cosmic rays were also found particles known as *mesons* which had been previously supposed in theory by the Japanese scientist Yukawa as the particle holding the protons of the nucleus powerfully together.

After the theory of atoms was first expounded by Dalton vast progress has been made in the field of nuclear physics. Max Planck and Niels Bohr first suggested the quantum theory which states that energy is released in packets or quanta when electrons in an atom hops from one orbit to another. Thus the belief that the energy was released continuously was refuted. Later more complicated quantum mechanics was developed by the Nobel Prize winners Max Born, Schrodinger, Heisenberg and de Broglie.

Two schools of thought now exist which support the corpuscular and the wave theory of matter.* Einstein established in his famous equation $E = mc^2$ a relationship between mass and energy. Thus some scientist have even claimed that atoms are merely waves of energy. Perhaps, in the future, some scientist will prove that men are not made of flesh and blood at all but are merely a mass of electromagnetic waves.

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* This is not correct. According to all physicists material particles as well as photons possess a wave as well as a corpuscular character.

—*Ed.*

Atoms and Molecules

ESSAY 3

Prodipto Ghosh
Delhi Public School
New Delhi

During the middle ages, interest in the sciences dealing with matter was confined to alchemy—the search for the 'philosopher's stone'. It was a widely believed fallacy that a mere change of colour of a metal was a sure indication of its transmutation into gold. So seriously were these alchemists taken by the ignorant public that King Henry VII issued a proclamation exacting heavy penalities on those who 'multiplied gold and silver'.

Though the search for the 'philosopher's stone' was unsuccessful, nevertheless, these ancient alchemists made some useful contributions to medieval industries. Quantitative chemistry, however, was entirely ignored and their searches were purely restricted to qualitative aspects of matter.

Ancient Greek philosophers, whose surmises tally astonishingly with modern findings were the first to speculate on the inherent nature of matter. To them, it appeared inconceivably absurd that the process of division and sub-division of matter could continue *ad infinitum*. Their hypothesis, that the division and sub-division of matter could proceed only up to a definite limit, up to the stage of 'atoms' and no further, bears an astonishing resemblance to Dalton's Atomic Theory.

Of the various laws of chemical combination, the one which led directly to the founding of the modern Atomic Theory was Gay Lussac's law of chemical combination in gases. He observed, that gases under the same conditions of temperature and pressure combine in integral parts by volume, these parts being always in the ratio of simple whole numbers. While this law is true only to the limits to which Boyle's and Charles' laws are true, it led to the enunciation of the famous Avogadro's hypothesis: 'Equal volumes of gases under the same conditions of temperature, and pressure contain the same number of molecules.' This was the first instance of the hitherto unaccepted concept of matter being composed of integral finite units being used to explain an established law.

The modern atomic theory owes its concept to the ideas of a Manchester school master named John Dalton. In the nineteenth century he enunciated his famous atomic theory of matter.

Certain laws of chemical combination—the law of multiple proportions and the law of reciprocal proportions were inexplicable on the basis of the concept that matter is divisible indefinitely. Dalton's Atomic Theory entirely satisfied and explained these laws. Briefly his theory may be

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stated thus :

Matter may be divided into two groups of pure substances, viz., elements and compounds. Elements are incapable of further separation into simpler substances while compounds may be divided until their constituent elements have been entirely separated. All forms of matter are incapable of existing freely beyond a certain stage, the particles of that stage being the integral unit, as it were, of that substance. The molecules of a substance however are capable of sub-division into atoms, the word being derived from Greek *atomos* meaning indivisible. The molecules of compounds consist of atoms of different kinds, while the molecules of elements consist of atoms of the same kind, the number of different kinds of atoms being the same as the number of different elements, each kind of atom being characteristic of one particular element.

Dalton's Atomic Theory laid the foundation for the concept of atomic weights, on which much of the reasoning of quantitative chemistry is based. It is inconceivable to 'weigh' a single atom of a substance and express its mass in terms of conventional units (gramme, pound etc.). The weights of different types of atoms were thus expressed compared to the weight of a single atom of a standard substance, i.e., hydrogen. Later the adoption of the hydrogen atom as the unit of atomic weight was found to be unsuitable owing to the fact that it was always contaminated with 'heavy hydrogen' or deuterium, and instead all atomic weights were expressed in terms of the atomic weight of oxygen which was taken to be 16.* On this scale, the atomic weight

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* Heavy hydrogen was discovered long after O = 16 had been adopted as the standard atomic weight. O = 16 was adopted as the standard because the atomic weights of

W.B.
Date 26.8.05
1854

of hydrogen is 1.008.

The laws of multiple and reciprocal combinations could be explained and with the help of atomic weights, quantitative chemistry came into general usage and investigation.

According to Dalton an atom was the ultimate unit of matter. Not only were they incapable of further sub-division, they were also incapable of transmutation into other types.

It had been noticed in connection with investigations on the nature of electrolysis, that during motion in an electrolyte ions appeared either to gain, or lose definite units of weight. This phenomenon was not sufficiently explained at that time. Becquerel's discovery of radioactivity, in his words, 'the spontaneous unrestricted emission of energy by uranium' was another inexplicable phenomenon. The discovery of cathode rays, the passage at high speed of charges between two terminals, charged to a high potential difference and placed apart in vacuum led to the discovery of the electron and the nature of electricity. Very significantly, it was realised that these negatively charged particles having integral* mass were constituents of atoms, and the concept of the indivisible atom was thus shattered.

Electrons however are integral charges of negative electricity. Atoms in general, however, normally do not possess negative charge and are neutral. It was argued, that if electrons were constituents of atoms, then there must be further consti-

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a large number of elements were determined from their compounds with oxygen.

—*Ed.*

*It is not clear what the writer means by the statement that these negatively charged particles possess integral mass.

—*Ed.*

tuents which were positively charged, as otherwise not only would atoms be normally negatively charged, but negatively charged electrons repelling each other would cause all atoms to break apart. From these considerations, and from investgiations on the emissions (∝, β and γ rays) of radioactive substances, the present concept of the atom was formulated.

Each atom consists of a central nucleus, at which almost all the mass of the atom is concentrated. These nuclei consist of *neutrons*, (so named because these particles possess no electric charge), and *protons* which are heavy particles carrying a positive electric charge of the same amount as an electron. In addition, nuclei may contain other stable and unstable atomic particles, mesons, positrons, pi mesons, etc.* Around this central nucleus orbit electrons in a manner analogous to the revolution of planets around the sun in the solar system. The number of orbits and the number of electrons in each orbit varying with different kinds of atoms, as also the structure of the nucleus. There was one flaw in this reasoning which, however, conformed to observed and predicted phenomena—i.e., since protons were electrically positive, it seemed incredible that these like charges would reside within the nucleus without their mutual forces of repulsion causing the nucleus to disintegrate. For a long time no explanation was forthcoming, until it was conclusively proved by experiment that the forces of repulsion of protons vanish and then change to those of attraction when the proximity of the protons is very close.

The phenomenon of radioactivity could now be explained and also why it was observed only in elements having heavy atomic weights. The complex nature of the nuclei of these elements makes them unstable with the result that disintegration of atoms takes place with consequent release of energy. This disintegration leads to the transmutation of elements into lighter atoms of lead. The phenomenon of radioactivity is said to be exhibited by all elements having a greater atomic weight than lead, although in the case of a few elements this transmutation is so slow as to be incapable of detection with the most sensitive instruments.

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* Mesons, positrons, pi mesons, etc., do not exist inside the nucleus which consists only of protons and neutrons. —*Ed.*

The concept of a universe of 'solid', indivisible and integral matter was thus reduced to the concept of a universe of electric charges. It was due to Einstein, however, that distinction between matter and energy ceased when he enunciated his famous law of relativity and related matter and energy by the simple relation, $E = mc^2$, where E is the energy liberated by the change in mass of a disintegrating element, c being the velocity of light.

The discovery that nature herself practises transmutation (i.e., in the process of radioactive emission) led to speculation on how the dream of the ancient alchemist may be fulfilled. Transmutation was, however, sought to be practised by men in order that vast and practically limitless energy may be liberated and utilized for power generation and destructive purposes. The Second World War hastened scientists' efforts to seek a means whereby rapid transmutation of elements to release tremendous amounts of power could be achieved. Hitherto rapid transmutation or nuclear fission was possible in theory. If a few atoms of uranium 235 were smashed in order that a stream of high velocity neutrons were released, these neutrons would, colliding with the nuclei of other uranium atoms, cause them to disintegrate, thereby causing a chain reaction and releasing vast quantities of energy. The creation of the nuclear bomb by British and American scientists was a major break through in the dream of scientists to be able to disintegarate matter at will.

The thermo-nuclear or 'hydrogen' bomb is precisely the type of nuclear reaction occurring in the sun. Hydrogen atoms formed as a result of an ordinary nuclear explosion fuse together to form a heavier atom, that of helium, releasing in the process still greater amounts of energy.

Nuclear energy has already been harnessed to provide power for domestic and industrial uses. A major defect of present day nuclear reactions, however, is that they cannot provide controlled amounts of energy at will. A nuclear reaction once started cannot be controlled or stopped until all the fuel supplied to the reactor has disintegrated.* It is to be hoped that the present day research will solve the problem of controlling both nuclear fusion and fission and make future nuclear reactors used to generate power economical enough to compete successfully with conventional means of producing power.

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* It is not correct to say that nuclear reactors cannot provide energy at a controlled rate. The nuclear reactor can be shut at will and regulated to supply energy at a controlled rate. —*Ed.*

Chemistry in the Service of Man

ESSAY 4

Anil Kumar
M.L. Higher Secondary School
Narela, Delhi

Chemistry is that branch of science which deals with elements and compounds and their actions and reactions on one another. The science has a very wide scope. The study of all metals and non-metals, elements and compounds, inorganic and organic, come under it. It serves man in almost every sphere of life. Nowadays, it has become such an important part of our civilization that life without it is impossible. To quote Pandit Jawaharlal Nehru, 'Life today is governed by the offshoots of science. Look around you, and you will find that most of the things that you find are connected to science in some way or the other.' Chemistry is an important branch of science. One thing about chemistry is that it is just serviceable to man and does him no harm.*

The history of chemistry is very interesting. In the beginning alchemists had two main objects which led them to start the science of Chemistry. First they wanted the 'philosopher's stone'—anything that was touched by this 'stone' would atonce be changed to gold. The other object was to get a universal solvent. So they started experimenting and this led to the development of this science. People of many countries were familiar with this science in the past also. Ancient Indians also knew the science of chemistry. Morever, they used to extract metals. Today this science is mostly used for the welfare of mankind.

The services rendered by chemistry are very many. In every sphere of life it is helpful to us. To account fully for its services, let us consider the life of a person. He gets up in the morning when the newspaper awaits him Now what is a newspaper ? It is chemistry in disguise. It consists of news printed on a paper. Now paper is prepared chemically by mixing several things together. Our ancients used to write on leaves and tree barks. But today chemistry provides us paper to write on. Imagine if there were no paper what would happen to all of us and to our offices, schools and colleges ? All work will come to a standstill. Reading and writing would become impossible and we shall be no better than barbarians.

Again, man cleans his teeth by means of a brush and toothpaste. Now does he know that this toothpaste is made after long chemical researches ? When he takes his bath, he uses soap. Now how

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*It depends upon the chemist or the person who puts it into use. —*Ed.*

doeshe get soap, a common domestic article ? This is again due to chemistry. After long researches chemists have found a formula for soap. And now soap is a common article of daily importance.

Then he wears clothes of different types. Clothes are woven, coloured and bleached by different machineries using one chemical or another. Chemistry gives us fibres like nylon and terylene. These are not cotton or wool fibres but are chemically synthesized Artificial silk has also been prepared from cellulose. The result is that we can today find cheap silk. In the past it was possible only for the rich to wear silk clothes. But today anyone can wear silk and even more fancy clothes like nylon. Thus chemistry not only improves the quality of a thing but also manages to produce the same artificially much economically.

Then the man goes to his office in a bus or car, if he has one. Now you know a car cannot run without petrol and other oils. Moreover it has rubber tyres and tubes. Where does this petrol come from ? Petrol is a highly refined form of 'petroleum'. When naturally occurring 'petroleum' is purified chemically, we get a number of useful products, such as kerosene, wax and coaltar. Kerosene is used in jet aeroplanes, for illuminating purposes and for fuel gases. Coaltar is largely used in road construction.

Then he takes his meals in metallic pots or clay or glassware. Now this is again service through chemistry. Naturally occurring minerals (i.e., ores) are taken out from the earth. They are purified and metals are extracted from them. These metals are largely used as such or as alloys. For example copper is largely used for electrical wires, cables, etc. Then alloys, mixtures of two or more metals are widely used for making utensils, coins, machinery and statues. You know that brass is a common alloy, it is nothing but an alloy of copper and zinc in definite proportions. Similarly gun metal, bronze and steel are all alloys. Our industry wholly depends upon these metals and their alloys. Our machines, tools, railways, aeroplanes, guns, etc., are all made of alloys.

The next wonderful gift of modern chemistry is glass. Glass is a mixture of various fusible silicates, mainly one of an alkali metal and the other that of a base metal. The whole of our civilization depends upon glass. We use bottles of glass, glass screens, glass potteries and other things made of glass. Chemistry itself wholly depends on glass because it is the only article which is not attacked by other acids or alkalis except hydrofluoric acid. Now glass is of many types and different types are suitable for different purposes. Experiments are going on in Paris about roads of glass. Such roads will require no repair and they will be too strong to be broken even by hammering There is nothing to wonder if we start to live in glass houses in the future.

Not only this, chemistry serves us in the field also. We can produce more by using good fertilizers and seeds. These fertilizers are mostly nitrogenous compounds, produced in chemical factories. Our country has already started manufacturing these fertilizers. We get enough fertilizers from Sindri Works in Bihar. This has improved our farming.

Again in the field of medicine, the contribution of modern chemistry is still more wonderful. Most of the diseases, previously thought to be incurable, have now been almost controlled. We can today cure cholera, malaria, small-pox, plague and even cancer to some extent at early stages. Antibiotic drugs such as penicillin are improved type of medicines. Then there are streptomycin, synthetic and other drugs which have helped us in combating the diseases in many ways. We have, then, D.D.T. chloroform, phenol, etc.* Thus we see that in the field of medicine also chemistry is our great friend.

We use many salts and spices in our daily life. All these salts come to us after they have been chemically prepared and purified in factories. Suppose a dishonest dealer mixes some cheap, but harmful material in our daily food articles, we can get them analysed in a chemical laboratory. Thus we are saved from eating poison. Then what about this 'ghee'—which we use in our food as a primary substance ? This is also a chemical product. In view of the increasing population of the world it is quite impossible to rear so many animals to get pure ghee. So ghee has been chemically prepared from cotton seed or by hydrogenation of various vegetable oils. This ghee does not differ from the natural ghee in many respects.

All our luxury goods, e.g., plastic, perfumes, etc., are also prepared with the help of chemistry.

Even in nuclear science, chemistry holds its own. Various fluids used in rocket propulsion, are chemically prepared. Again it is utilized in the production of many explosives, e.g., T.N.T.

Above all, chemistry develops a sense of curiosity in man. And curiosity is life. The day when this curiosity will vanish human existence will become impossible. And what will be the use of the future to man surviving (if he could survive) as a mere clod of flesh and blood ? Thus

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**Note*:—Chemicals like D.D.T. chloroform, phenol, etc., help us in many ways for better health. —*Ed.*

it (chemistry) keeps the candle of curiosity burning. It inspires man to find out and collect truths and then to believe in them. It teaches them not to believe things which are not found to be true by experimental facts. Thus it teaches us honesty.

Again chemistry purifies our religious life. We ignorant people believe in superstitions simply because our elders did so. But chemistry puts them to test. If they are found false or wrong by experimental facts, they are rejected or otherwise they are accepted.

Thus we see that we live in an age of chemistry. We wholly depend upon it for our physical and mental needs. Whether this dependence is right or wrong is quite a separate issue over which we are not concerned here. It is, however, quite clear that chemistry is a great friend of mankind and man is highly indebted to chemistry for its acts of friendship.

Chemistry in the Service of Man

ESSAY 5

Mahesh Kumar Seth
St. Columbas' High School
New Delhi

Man put nature at his service, not through force, but by understanding it ; that is why he succeeded where magic failed. He looked for no spell to cast on nature. His understanding of nature has made the basis of science, which through its various branches is helping man in his needs. Chemistry, forming an important part of science, is helping man in no smaller way than any other part of it.

It serves man both during war and peace. In war, several explosive compounds are used for the manufacture of bombs and things which help in destroying people and laying land waste. But in peace time, certain compounds help to make people live longer and overcome diseases. Man is no longer afraid of diseases for he has an answer to nearly all of them. Chemistry is at his service—he may use it for destruction or for construction.

Atoms and molecules which are very small particles of elements and compounds also help man in some way or other. The fusion of atoms of hydrogen, for example, results in the liberation of a large amount of energy. Recently discovered metals like uranium are the sources of large amounts of energy ; for example, the fission of one pound of uranium is equivalent to the combustion of one ton of coal.[1] The atoms which help destroy things also produce isotopes which cure diseases like cancer.

Metals by their varied properties help man to use them for certain things while alloys acquire different properties for different uses. Aluminium, copper, lead, iron and a few others are of considerable use to man. Aluminium, being manufactured at the Aluminium Metal Works and other factories, is important because of its small resistance[2] to the flow of electricity. Aluminium and copper are both used for electric cables. Aluminium, copper, zinc and lead form important alloys like duralumin, bronze, brass, solder metal, type metal, bell metal, etc. Similarly, other metals form different alloys. Steel for the manufacture of machinery is very important for the development of a country. It is being manfactured in India at

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[1] The fission of U_{235} in one pound of natural uranium gives as much energy as about 30 tons of coal. —*Ed.*

[2] Although the electrical conductivity of aluminium is only about 60% of copper, but due to its lightness, aluminium is gradually forcing copper out of electrical engineering. An aluminium wire weighs only half as much as a copper wire of equal electrical conductivity. —*Ed.*

Bhilai, Rourkela, Durgapur, Jamshedpur and another plant is expected to be started at Bokaro.

Nitrogen-containing compounds are important for their use as fertilizers. These compounds when mixed in the soil provide the additional source of nitrogen and give better yields. Artificial fertilizers like ammonium nitrate and superphosphate are now being used all over the world. Important plants in India for the manufacture of fertilizers are at Sindri and Nangal.

Chemistry is at our service both on the field and at home. Washing soda is used by the washerman for washing, and the valuable stearate group which loosens dirt is used to form soap. The ignorant washerman uses soap to clean clothes but does not realize that it is chemistry which has helped in the formation of soap. Similarly, dyes are used for colouring materials and these dyes are nothing but chemical compounds which give their colour to the materials. The manufacture of drugs is from chemical compounds and research institutes help in finding out what effects certain compounds or groups of compounds have on germs' and bacteria. Chemistry has enabled man to make medicines for almost each and every disease. He is not now afraid of sepsis because he knows he has got penicillin to help him at the time of need.

Perfumes and cosmetics which give women their beauty and attract men towards them, are all formed by complicated chemical processes. Perfumes are made by the combination of certain compounds so as to produce sweet odour. Chemistry helps to form a wide range of things. Insecticides control the action of pests on plants, or other things which are useful to man. D.D.T. and chlorine are used to kill insects doing harm to man. Chloroform is an organic compound, tri-chloromethane, and is used in combination with other substances as an anaesthetic.

Plant fibres do not seem to satisfy man and he has now developed artificial fibres for his use. Nylon, terylene, decoron, and orlon have been developed by various complicated processes. Fibres like polyvinyl chloride are used for the manufacture of several articles ranging from fishing nets to table covers. Plastic is being used where other things were found to be useless. Besides these articles used everyday, the study of chemistry has enabled man to form strong explosives with sulphur and phosphorus.

Chemistry has been serving man since a very long time and since then its theories have been modified and each time it makes it all the more useful to man. Dalton's atomic theory which had been accepted since a long time has been modified by the study of the structure of the atom by Lord Rutherford. The modified theory enabled man to use the splitting of atoms to form a source of energy and power.

Chemistry has been very useful to all people, but in India it has taken some time and will take some time more before people drop their orthodox ways of life and use the facilities with which chemistry has provided them. Farmers, for example, are sometimes reluctant to use artifical manures for better yield and sometimes prefer field manures to the definitely better artificial fertilizers.

Chemistry has been developing since long, and the passage of each century means a change in several things. Scientists have always been trying to get something better out of something good. They are never at rest—always trying something new so that their experiments may benefit man. Among the recent discoveries is a substance called *flubber*. A ball of flubber rises higher each time it falls to the ground and this in due course will be used for something exciting, like an ever-rising balloon which will help in the study of space.*

Research in chemistry is in progress in all countries, each scientist trying to find out something new. It is their combined effort which will help man in the years to come. Scientists always try to make something new or something that will help man not to bother about the exhaustion of a naturally-occurring substance.

It is therefore, the earnest desire of all people to see that something new, something that will help man, may be discovered. There is no limit to the scope of chemistry and it will always be at man's service at his time of need as it has been in the past.

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*This is mechanically not possible. —*Ed.*

Chemistry in the Service of man

ESSAY 6

Inder Krishna Kapoor
St. Columbas' High School
New Delhi

It is an undisputed fact that chemistry has done wonderful things for man. Right from the smallest things, as a soda-water bottle, to the mighty things, rockets and satellites, for example, have come into being with the help of chemistry. Wherever we may go, we find it being applied for all sorts of jobs. Truly speaking, if this wonderful thing was not among us and we did not have the knowledge of it, we would be no better than the ignorant and illiterate early cave-man. Now, let us go deep into the matter and try and figure out the various uses of chemistry. God by giving us this boon dropped 'manna in the way of starved people'.

This subject has helped us immensely in extracting metals from their ores. These metals, mixed with others, form the most important alloys known to us. These alloys are used, as at times the metal itself is useless for certain purposes. Now that we know these methods of extraction, everything appears easy, but we all know that this is the result of the very hard labour of chemists.

The formation or rather the discovery of alloys has produced astounding results. After much labour we have come to know of the various steels, etc., which are used for various purposes. We have made certain alloys which are used in ships and jet aeroplanes. But how did this happen? This was plainly due to the fact that chemistry was the backbone of all the concentrated study that was carried on during the past.

The scientist with the help of chemistry has done things not known to anyone before. Just imagine what has been done. Hydrogen and oxygen have been combined to form water, the simplest and most important thing in this world. Not only this, the scientist has even gone further : he has broken up water to give hydrogen and oxygen. He has told us that common salt, which forms part of our diet, is made of two most dangerous things. One is sodium, a metal which cannot be touched by a finger, and the other is chlorine, a most poisonous gas.

In agriculture, chemistry has been blessing in disguise for the farmers because it provides them with a fertilizer—artificial manure. Just look at the stuff used, ammonium sulphate, and it does not strike us that it can be used for such a purpose. Yet the chemist and the scientist after repeated experiments have created this thing. In these times, when a vast development is going on, India is not behind anyone. She has her own fertilizer factories. This is actually a good thing because the drain on foreign exchange is cut down as this item has not to be imported. The result of all this is that crops are abundant and the production is twice as much. This step reduces the risk of a famine which no country can afford when its population is increasing by leaps and bounds.

Among other important things is glass. This seems quite a simple commodity but has many uses. It is used for making glass tumblers. Glass vessels such as flasks, pipettes, burettes, funnels, and other important articles used in the laboratory are made from it. It is also used for making windowpanes for houses, trains, ships and aeroplanes, and for lenses and mirrors used in telescopes. It has other innumerable uses owing to the fact that it is transparent. All this is due to chemistry because this branch of knowledge helped a lot in investigating the properties of glass.

Let us, for example, take the case of a soda water bottle. It is a very simple thing and yet for some, a very complicated thing. In this a considerable amount of carbon dioxide is enclosed under pressure. When the cork is released the gas escapes and this produces bubbles.

In order to live in this world and to mingle with society, one has got to remain neat and tidy. For doing this, man has invented soap which is made from fats and caustic soda.

Perhaps the greatest service rendered to man by chemistry is in the drug industry. Sometime ago there was no remedy for certain diseases. There were no good doctors and no good hospitals. However, as time passed, doctors and hospitals came into being and later good medicines.

Imagine the case of man who got tuberculosis.

A few years back there was no remedy, but now a man suffering from this disease can be cured. Some diseases cannot be cured but it is hoped that chemistry will play some part in the invention of new drugs.

All men and women owe a lot to chemistry. They move all over the place wearing the most gaudy clothes. Little do they realize that their clothes have been tailored from cloth which has been bleached and dyed with the help of knowledge derived from chemistry.

All perfumes and insecticides for which we do not care at all are really the result of the concentrated study and experiments by chemists.

These days a good many things are made from plastic. This is a complex substance made up of various things and can be moulded into any shape. Beautiful toys, pens, pencils and other things can be made from it. Not long ago, it was believed that there were no artificial fibres. But subsequently the chemists have discovered artificial fibres. With the help of chemistry we know the proportion in which certain things are mixed to form dangerous explosives.

In the case of fires this art is used by firemen. As soon as they are called to put out a fire, they arrive with their water hoses. If there is a small fire it is extinguished by means of a fire extinguisher. This usually consists of a container packed with calcium carbonate.* The container also contains a bottle filled with an acid. When the bottle is broken, the acid reacts with the calcium carbonate and carbon dioxide gas rushes out so as to put out the fire.

Knowledge of chemistry is used by doctors and surgeons when major operations are performed. The patient to be operated upon is given chloroform, an organic substance. This makes the patient senseless and he does not feel any pain when the diseased part is being removed. In minor operations doctors use laughing gas which is nitrous oxide. A dentist also takes the help of chemistry in extracting a tooth. The patient is given nitrous oxide. This makes the patient insensible to pain and the dentist is able to remove the tooth easily and painlessly.

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* Actually sodium carbonate is used. —*Ed.*

Certain chemicals are used to preserve dead bodies. These are useful for coaching the students who are to become the doctors of tomorrow.

This is the age of rockets and satellites. Even these things work according to certain rules and regulations formulated in chemistry. Before a rocket is projected into space the distance it has to travel is calculated. Accordingly the fuel is filled. The fuel in this case is liquid hydrogen. The rate at which this burns is found by means of chemistry. Therefore, it can be seen what an important part chemistry plays in space travel.

This subject is also helpful in the preservation of food. Food kept in refrigerators does not go bad. The food value is also maintained and we can take it whenever we want.

Chemistry plays a part in the extraction of certain oils and fats. Hydrogenation is an important process. In this process the oil which is liquid in the beginning is made into a solid by passing hydrogen into it for a fixed time.* This makes the oil suitable for cooking purposes. Chemistry is also useful in separating certain things. If a mixture of two things is given to us we can separate them, provided they have the property of crystallising at different temperatures. This can be done by the method of fractional crystallization. A saturated solution is prepared and crystals are obtained. The crystals of the two substances form at different temperatures.

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* Hydrogenation requires a catalyst and some definite conditions of temperature. —*Ed.*

Chemistry is blessing in disguise for man. It has innumerable uses in all walks of life. Had it not been known to us, we would have suffered immensely. This subject has given a great power in our hands and it is possible for us to do anything. It is popular these days that it is taught all over the world. Gone are the days when famine, illness and other dangerous things could frighten man. He is now the master of all things. In days to come, chemistry will make still further progress.

Vitamins

ESSAY 7

Kamaljit Kaur
Delhi Public School
New Delhi

Vitamins or the 'accessory foods' form an essential part of a man's daily diet, as they are vital for maintaining a strong and healthy body. Besides carbohydrates, proteins, salts, and fats, the body also needs certain substances for its upkeep and for developing resistance against infectious diseases. This is provided by the vital vitamins.

The absolute necessity in the diet for vitamin was first shown to be true by Hopkins.* He carried out various experiments on rats. He included various foods in their diet : rice, wheat, pulses and lentils, and of course water. The rats gradually became weak, and they lost weight and died soon after. Now Hopkins felt that there was something which was lacking in their diet. He now fed the rats on wheat, rice and pulses, as before, but added some milk and raw vegetables to the diet. The rats became healthy and no longer died. Thus he called milk, eggs, vegetables and certain fresh fruits which contains vitamins as 'accessory foods'.

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*Hopkins was one of the experimenters who discovered this fact. *—Ed.*

Not only are vitamins important accessories in the diet, but they are also protective foods. Certain diseases which are caused by deficiency of vitamins are entirely eliminated if the required vitamins are included in the diet. Vitamins are found in all green leafy vegetables, fresh fruits and certain root and stem vegetables which are 'underground vegetables'. They are found in natural foods as well as in meat and fish. Meat and fish give strength to the body and build up its resistance which makes the body able to fight infection.

Long ago, before Hopkins carried out his successful and revealing experiments regarding vitamins, most of the vitamin deficiency diseases were dreaded by the people. Scurvy, one of the deficiency diseases, was the dreaded disease of the sailors. It was found that most of the sailors of the topical seas developed scurvy. Their hands, feet, arms and legs would get swollen. The joints would therefore become stiff, causing great pain. When, however, lemon juice was given to the scurvy patients, they gradually became all right. At that time, they did not know that this was because lemon juice contained vitamin C.

Today, for most deficiency diseases, vitamins are the preventive measure as well as the cure. There are many vitamins, the chief of which are vitamins A, B, B_2, B_1, C, D, E, F, K and P.* All these vitamins are equally useful and if each is taken in the small quantity which is necessary, we would be able to get rid of many diseases.

Vitamin A or the anti-infective vitamin builds§ up white cells and strengthens them against the attack of disease bacteria. Vitamin A is fat-soluble and is found in carotene, which is found in plants. It is destroyed by prolonged heating and exposure to air. Red palm oil, an oil found in the tropics and South America, is the richest natural source of vitamin A. This vitamin is also found in carrots, turnips, spinach, cod liver oil, shark liver oil and meat. Not only does vitamin A build up the body and protect it against infection, but it also prevents 'night-blindness'. It is very important for the prevention of Xerophthalmia and Keratobalmia, both of which are diseases of the eye. It is a necessary factor for the maintenance of good eye-sight. Deficieny of vitamin A will result in the above mentioned diseases. The body will not be able to resist infection, and will be infected by disease bacteria at the slightest provocation. The reason is that the white corpuscles will not be strong enough to kill the bacteria, and will be engulfed and absorbed by them.

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*Main vitamins needed by man are A, B_2, B_5, B_1, C, D_2, D_3, E, H, K_1, and Choline.

§Vitamin A helps in the building up of white cells. It is helpful in maintaining resistance to infections. —*Ed*

Vitamin B, or the anti-beriberi vitamin is very important, essentially for the people living in the tropics. Beri-beri is caused by eating polished rice. Brown rice is very rich in vitamin B. When rice is polished it loses most of its vitamins. The reason is that the husk or outer covering of the grain which is very rich in vitamin B, is destroyed. So when people eat polished rice they are not obtaining the needed quantity of vitamin B. Eating polished rice is not uncommon. Not only does it create a deficiency of vitamin B, but it also causes beri-beri. Vitamin B, as such is water-soluble, and like vitamin A, is destroyed by prolonged heating and exposure to air.

Pellagra is a skin disease which is common in countries where maize is the staple diet or forms an important part of the diet. For people who eat maize, vitamin B_2 is essential, so that they may not be exposed to pellagra infection. Pellagra is also caused by lack of the vitamin, niacin or nicotinic acid (a B-vitamin) which is called the antipellagra vitamin.

Vitamin B_2 (ribo-flavin, a growth promoting vitamin) helps in the formation of blood. Its continued absence may lead to pernicious anaemia.* It is found in liver, kidney, yeast, tomatoes and marmite. It is also found in green vegetables to some extent. Tomatoes, especially raw, ones are a good source. Brown rice is one of the sources, provided it is not milled or polished. Being a vitamin of the B-group, it is water-soluble, and it is destroyed by prolonged heat and exposure to air.

Scurvy, the dreaded disease of the sailors, is caused by the deficiency of vitamin C, which is water-soluble. Vitamin C is very easily destroyed by heating and is therefore absorbed in the largest possible quantity when its sources are eaten raw. It is found in lemons and all citrus fruits. Citrus fruits include fresh fruits like sweet limes, oranges, maltas and other varieties of lemon, both sweet and sour. It is also found in green chillies, and spinach. Vitamin C cools the body and when taken by people in the tropics, is specially so, since it prevents the appearance of pimples and boils on the surface of the body. Vitamin C is also required for the manufacture of blood plasma, and for the formation of haemoglobin which is the red colouring matter in the blood. Ascorbic acid is another name for vitamin C.

One of the unusual vitamins is vitamin D. It is formed in the skin by the action of the sun's rays. The rays of the sun act on the skin, produc-

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*Pernicions anaemia is caused [by the deficiency of vitamin B_{12}.
—*Ed.*

ing a substance called ergosterol.* Vitamin D or the anti-ricket vitamin is found in milk, cheese and eggs. It is not destroyed by heating or exposure to air. Like vitamin A it is also fat-soluble. Vitamin D is essential for the building up and the strengthening of bones and teeth. If enough vitamin D is not taken, the bones become soft. That is why infants and small children are given milk to drink, so that their bones may become strong. For this reason, milk is their staple diet. Softening of the bones in children causes rickets, while the same disease in adults is called osteomalacia. Vitamin D is also needed for the absorption of calcium and phosphorus compounds by the body.

Vitamin E (tocopherol) is the anti-sterility vitamin. It is found in the germs of wheat and rice, and is essential for reproduction.

Vitamin F serves for the building up of the body. Vitamins K and P are found in apples, pears, milk and green vegetables. They are essential for the clotting of blood and also to prevent the blood from leaking out of the blood vessels. Lack of these may cause haemophilia, and it is possible that if the person has haemorrhage at any time, the bleeding may not stop for a long time, and thus result in a great loss of blood from the body.

Deficiency diseases are caused due to the lack of proper vitamins in the food. The treatment for such diseases is to ensure that the diet contains the required quantity of all the vitamins. For example, vitamins C, K and P are necessary for the clotting of the blood ; vitamins A, B and D are required for building up the body and vitamin D

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*Vitamin D is produced in the skin by action of sun-rays acting on ergosterol already present there. *—Ed.*

for the bones. The foods which contain almost all the vitamins are few. Milk, for example, contains all vitamins in quantity except vitamin C; eggs contain almost all the vitamins. However, green vegetables and fresh fruits are the best natural sources of vitamins except vitamin D.

Fruits like apples increase the iron content of the body, besides containing vitamin A which is the anti-infective and the growth-promoting vitamin. Green, leafy vegetables, like spinach, contain vitamins A and C. Green vegetables and chillies contain vitamins A and C and small quantities of vitamin B.

If a man eats a meal consisting of unpolished rice or wheat, pulses, green vegetables like spinach and pumpkin and eats fresh fruits and takes about two tumblers of milk a day, his diet is not lacking in vitamins. Of course, meat and fish, and other animal foods, provide building material in the form of proteins and are thus good from the point of view of the growth of the body and the upkeep of its health. All these foods would form a perfectly balanced diet.

The quantity of vitamins needed depends upon various factors. The more important amongst them are age, sex, season and climate; At the age of one to fourteen years, more vitamin D is required. This is so because it builds up the bones and teeth. Vitamin A is also needed to a large extent for growth. It is at this age that the child really grows, and since the food eaten is being consumed more rapidly, more nutritious food containing vitamin A is required.

Vitamin D is of great importance to nursing mothers. The climate also governs the amount of the vitamins needed. In cold climates, less vitamins K and P are required; whereas in hot climates, more vitamins K and P are needed. The reason is that in high altitude regions, the bone-marrows are capable of producing red-blood corpuscles soon, whereas at low altitudes, more vitamins are required so as to make the bone-marrow form more red cells. If the intake of these vitamins is not enough, people develop anaemia. As far as the seasonal effect is concerned, there is little variation, except that in summer more vitamin C is needed than in winter. This is mainly due to the cooling effect exercised by vitamin C. That is why more oranges or maltas should be eaten in summer, so that the body may remain cool.

Vitamins thus play a very important role in man's daily diet. When they are taken in the correct quantity there is little danger of infection or disease. These important foods, which Hopkins termed 'accessory foods', are indeed 'essential' for the growth and building up of the body. Vitamins maintain vitality of the body, good health, strong bones, firm teeth, and the growth of the body is ensured with the inclusion of vitamins as a primary part of the daily diet.

Organic Evolution

ESSAY 8

B. Sunder
M.E. Higher Secondary School
Lodi Estate, New Delhi

From ancient times, man has thought over the origin of life. The Christians believed in the theory of special creation and the theory of spontaneous origin came later. These were after all like various superstitions and beliefs, inaccurate guesses which were not supported by constructive and positive evidences.

The idea of evolution is a considerably modern one and is certainly more acceptable than those mentioned above. This theory puts down that life originated as a speck of protoplasm, which is the physical basis of life. Gradually, the living things became more complex to suit the changing environment, i.e., through the millions of years life evolved and as a result of this phenomenon, we have the fauna and flora of the world, seen all round us.

The idea of organic evolution stood its ground because it was supported by evidences, direct and indirect, circumstantial and non-circumstantial.

The best evidence to this concept comes from palaeontology, a branch of science dealing with fossils. The sedimentary rocks, i.e., those formed in layers through the years contain a vast store of information. If the theory of special creation were true, one would expect to find the fossils of the same animals in all layers. On the other hand, the concept of organic evolution demands that the fossils in the lower strata should be simpler and those above more and more complex as we proceed upwards. Actually this is the case. Although the remains of the animals and plants have not been preserved intact, there is a clear indication to prove the theory of organic evolution.

In the Precambrian age fossils, no signs of life are found. On the strata representing the Cambrian age are seen the early and simple forms of life. As we proceed through the various strata upwards, we find the fossils of invertebrates, fishes, amphibians, reptiles and mammals in a regular order. Fossils of men have been found only from the Pleistocene era. Thus the evidenc from palaeontology is the most direct support for evolution.

Embryology is a study of the embryos of various animals. It is seen from a study of the embryos of the higher animals that they pass through certain stages and have certain organs. For example, as the frog passes through its metamorphosis, it develops gills like a fish, has a tail like a fish and is herbivorous. But as it becomes an adult, it loses all these. Similarly, the human embryo as it undergoes development in the uterus of the mother, shows gills like a fish.*

As the frog undergoes its development in water, the gills and tail can be explained as development to suit its environment; but why does the mammalian embryo develop such useless characteristics like gills and so on ?

Moreover, the embryos of various animals resemble each other at certain stages of their development. The closer their relationship in the animal kingdom, the more do they resemble each other in the embryonic stages.

These interesting phenomena can be explained only on the basis of *organic evolution*. As Haeckel put it 'Ontogeny repeats phylogeny', i.e., an animal in the course of its development repeats the stages or phases, though in a summarized way, through which the whole phylum or class has passed in its onward march of evolution. For the same reason embryos of animals bear resemblances at certain stages of their development.

How has evolution taken place ? What laws have governed it ? This has been the question which many scientists have explored.

The first important theory to explain evolution was put forward by Lamarck. His theory is known as the *theory of acquired characters*. His theory is based mainly on three points.

1) Environments change in this world.
2) Use of an organ improves it while disuse makes it weaker.
3) The characteristics acquired by an animal during its life-time are passed on to the next generation.

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*Human embryo does not show any gills like a fish. Only the rudimentary gill-stetsare present. —*Ed.*

Lamarck said that with the changing environment and living conditions, an animal may have to use some organs more than others. Naturally, he said the organ that is constantly used will improve and grow stronger and the organ which finds no use will become weaker and weaker. When this animal reproduces it will produce offspring having the same organ stronger, and so on with the generations until the change becomes appreciable to distinguish the animal as a new species.

Lamarck took the case of the giraffe to support his views. He said that the giraffe had once been a short-necked grass eating animal. In course of time the grass grew scarce and the giraffe turned to the leaves for food. As it had to stretch its neck to reach the leaves of higher trees, its neck became longer by constant stretching. The next generations received this acquired characteristic from the parents until we have the present day long-necked giraffe.

His theory ran into heavy weather. Many scientists opposed it. They said that acquired characters could not be inherited because these did not affect the genes of chromosomes. Therefore Lamarck's theory was not accepted.

Darwin, an English scientist, put forward his *theory of natural selection*. He based his theory on certain facts and derivations.

i) Tendency of animals to reproduce in enormously large numbers Darwin noticed that in this world animals as well as plants have a tendency to reproduce much faster than the death rate and thus increase their number quickly.

If a pair of flies started laying eggs now and if all the offsprings survived, in a year there would be millions and millions of these, thus crowding the earth and causing wretched diseases.

ii) *Constant Numbers*. But the number of animals of a certain species remains practically constant. Darwin noticed this fact also.

iii) *Struggle for existence*. Darwin put facts, (i) and (ii) together to build up the derivation that a struggle for existence is continuously going on between members of the most closely related species as well as those which are very different from each other. This struggle, he said, may be an apparently passive one, or kill-or-be-killed type of struggle.

iv) *Favourable varieties*. Darwin said that not all members of the same species, even those of the same family are all alike.* Actually noticing closely, there is considerable difference or variations between the animals. Some animals possess favourable variation which place them above others and so give them a better chance to survive. This is clearly mentioned in the next point.

v) *Survival of the fittest*. In this contest for existence, Darwin said those who possessed variations favourable to them survived while those which did not have such variations died and thus gave way to the better adapted ones. This Darwin refers to as the survival of the fittest.

vi) *Inheritance of favourable variations*. Darwin said that as animals with the favourable variations survived, their offsprings were also born with these advantageous variations and thus continued to do well in the contest for life.

vii) *Origin of species*. Darwin said that as the centuries passed by, the animals that lived became more and more modified to suit their environments and so became completely different from their ancestors. Thus a new species came into existence.

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*Not all members of the same family, even those of the same species are all alike.
—*Ed.*

Darwin's theory was also not readily accepted. He was opposed mainly on the following points :

i) Sometimes even persons with the most favourable variations lose in the battle of existence to the lucky ones.

ii) The favourable variations of Darwin were only phenotypic ones and so they could not be inherited.

iii) Thirdly such small variations did not cause a new species.

The latest theory was put forward by Hugo DeVries. His theory is called the *mutation theory*.

He was experimenting with evening primrose, when he found out that among the usual plants there were ones entirely different from the normal ones. He termed these new plants *mutations*. These plants on reproduction gave rise to offsprings like themselves.

DeVries argued that only by mutations did evolution take place.

His theory is more acceptable than the other two because, mutations are variations due to the effect of change in genes of the chromosomes, i.e., they are genotypic.

New species have been evolved more recently due to cross breeding or hybridization. Thus new and more healthy maize plants have been evolved from older types. Hybridization also plays an important role in developing plants with improved characters and thus producing better seeds.

On examining the divisions of the animal kingdom as a whole, it seems more like a big tree with numerous branches. Man is very recent and so forms one of the terminal branches of this tree. Man appears only in the Pleistocene age. The fossils of early man indicate that man and apes and chimpanzees are very closely related. Actually the early man as the Hendenburg* man resembled the ape.

Thus we see that man or *Homo sapiens* is the most modern and advanced animal in the world possessing the sixth sense.

The modern theory to explain evolution is a combination of Darwin's theory of natural selection and Hugo DeVries' theory of mutation. It believes in the struggle for existence and survival of the fittest, but does not accept that Darwin's phenotypic variations are responsible for the origin of species. It takes into consideration only genotypic variations or mutations as the basis for origin of new specie. This is the modern concept of origin of species and is the most accepted one.

The concept of organic evolution is further firmly supported by evidences from classification, evidences from geographical distribution and from physiology.

Classification of animals into classes, phyla, orders, families, genera, and species are only explained by supposing that they had a common ancestor.

Moreover, this system of classification is not something incidental but is actually based on the relation existing between the animals. This system of classification serves as a concrete evidence for organic evolution.

The concept of organic evolution is a revolution resulting from man's developing intellect and his dissatisfactions at having to accept some theories not based upon evidences.

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* Heidelberg man. —*Ed.*

Organic Evolution

ESSAY 9

Geeta Trivedi
Lady Irwin Higher Secondary School, New Delhi

The fact that life has been existing on the earth for millions of years is undeniable due to the evidences gathered by many scientists through the ages. Yet, there is controversy as to the origin of species. How did the plants and animals in such variety come on the earth ? Were they all created at a time, or did they give rise to one another as the years passed ? We cannot say for certain that this happened or that happened, for none of us were there when the world first came into being. Many theories have been put forth, considered and rejected as being false, but we have made some headway with the subject. Some of the old theories are :

(*i*) *Theory of Eternity of the Present Conditions*. Among the first to be suggested, this theory states that life has been continuing in its present state through all the ages—there is no vestige of a beginning and no prospect of any end. Yet, we see life in the form of various plants and animals being born, and dying. This theory was completely discarded.

After this the Church authorities propounded the theory of *Special Creation*. According to this, God made matter the first day, breathed life into it on the second, and created plant life in its full variety on the third day. On the fourth day he created all the animals as we see them today. On the fifth day, he created Man out of nothing and on the sixth day, he created Woman out of Man's own ribs.

This theory found great favour with the people and the Church authorities for a long time, till an explorer, Cuvier, discovered the fossils of the old age animals, long extinct. This stood against the theory of special creation. So he modified it to put forward the theory of *Catastrophism and Subsequent Creation*. According to this, there have been occasional upheavals on the earth, completely destroying all life on it, and again, new varieties have been created.

But even in the old ages while people were blindly following the simplest explanations put forward to them, there were people like Democritus, Buffon, Aristotle and Erasmus Darwin, who did not believe in these theories but believed in evolution of descent with modifications. They believed, that life came to the earth in simple single-celled forms, which gradually got modified, so that their characteristics changed and they gave rise to new species. These modifications were due to certain forces in nature which were the causes of these effects.

It was in considerably later years that Charles Darwin, put forward evolution as a theory to explain the origin of species. He was the grandson of Erasmus Darwin and was greatly influenced by him. He was on the ship *Beagle* for five years, collecting data and information in support of evolution. These facts he put down in his book *Origin of Species.*

The evidences in support of evolution are many and strong :

(i) *Classification* of animals shows a relationship between them. For example, all cats are grouped under the family* *Felis.* The domestic cat is known as *Felis domestica.* This along with the other wild cats, lions, leopards, i.e , great cats, comes under the family* *Felis.* Now all carnivores, i.e., flesh eaters, having sharp canines like dog, cat, bear, etc., are classed under the Order Carnivora. These carnivores, along with whale, monkey, etc., belong to Class Mammalia for they have a covering of hair on the body, and they give rise to live, well formed young ones which are suckled by the mother. The mammals along with fishes, birds, reptiles, etc., come under sub-phylum Vertebrata, for each has a vertebral column replacing the original notochord. These along with others belong to Phylum Chordata, and finally all the animals are classed under kingdom Animalia. So, we find that classification follows fixed rules by similarities so that it shows that all animals have descended from the same original stock and still retain certain similarities.

(ii) *Homologous organs*: Certain organs of different animals which are so widely different in looks as well as function, like the paw of rabbit meant for digging, the wing of bat meant for flying and the paddle of a whale meant for swimming, have basically the same structure. Each consists of humerus, radio-ulna, carpals, meta-carpals and phalanges.

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* Genus.

(iii) *Ontogeny repeats phylogeny :* All animals during their individual development repeat the development of their race, *i.e.*, 'Ontogeny repeats phylogeny'. Taking the case of a frog, the single celled egg resembles the protozoa ; gastrula—trip-loblastic stage ; tadpole—fishes.

Similarly, in the development of the human embryo, it undergoes these stages. We find a stage with external gills in the human foetus (which are not used).

(iv) *Progressive structural modifications in the organs of animals :* The heart of fish consists of one auricle and one ventricle with a one-way flow of blood maintained by the cilia.[1] In frog (Amphibia) there are two auricles and one ventricle. In some reptiles, e.g., alligator, the ventricle is partially divided and the truncas is present. Finally, in birds and mammals there are two auricles, two ventricles and three aortic arches.

(v) *Vestigial organs :* Certain structures are present in man as vestiges which are not used (in fact, are sometimes harmful—e.g., appendix) by him, but are present in lower animals and are very useful to them. For example the vestigial nictitating membrane in men is practically of no use whereas in fishes[2], it forms a protective covering to the eye. In certain pythons, relics of the hind limbs and pelvic girdles are present showing that they have evolved from ancestors possessing those organs.

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[1] No cilia present.

[2] Only in some fishes.

(vi) *Palaeontological evidences* : The history of the earth has been divided into three main eras which are further sub-divided. In these, from the palaeontological evidences, like fossils and casts, a good picture has been drawn showing the trend of evolution as given below.[1]

Cenozoic	Recent	Men
	Pleistocene	
	Pliocene	Distribution of birds
	Miocene	birds and mammals
	Oligocence	
	Eiocene	
Mesozoic	Cretaceous	—Remains of reptiles and beginning of birds and mammals.
	Jurrassic	—Dominant age of reptiles.
	Triassic	—Development of reptiles.
Palaeozoic	Permain	—Amphibians and beginning of reptiles.
	Silurian	—Beginning of amphibians.
	Carboniferous	—Dominant age of fishes.
	Devonian	—Beginning of fishes and remains of marine invertebrates.
	Cambrian	—Fish-like organisms. Marine invertebrates.
	Precambrian	—No life.

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[1] The sub-divisions of some eras and appearance of certain living forms are not in correct sequence. —*Ed.*

(vii) *Atavism* : Even in these days, there is atavism or reappearence of ancestral characters like the tail in a human body or long hair on the face, showing, that sometime, in the development of the race, these characters were present.

(viii) Precipitin tests and haematin crystal tests show the relationship between different animals.

(ix) *Connecting links* : Certain animals' fossils have been found which form links between different animal groups. Thus a bird-like organism, e.g., *Archaeopteryx* had a beak with teeth, a tail on which feathers were arranged and wings with three claws. It is a transition form, between birds and reptiles.

All these facts stand strongly in support of evolution. But again, there is a controversy as to the mechanism of evolution or exactly how evolution has taken place. Great scientists have put forth theories to explain it. Some of the theories are :

LAMARCK'S THEORY OF ACQUIRED CHARACTERS

According to this, with changing environment of the world, animals have to face changing needs, and there is a conscious effort on the part of the organism to adapt itself to its changed environment. This involves the use of certain organs and disuse of others. The organs that are useful develop while the organs which are not useful get atrophied. Thus, if a horse-like animal was forced to retire to arid conditions, it would not find grazing grounds. It would have to take the leaves from trees for which it would have to stretch its neck, and this would get elongated. This acquired character would be passed on to generation after generation till we got the present day giraffe.

This theory, though quite simple, is not wholly acceptable. Thus, Weismann, who believed in the continuity of germ plasm, performed several mutation* experiments by cutting off the tails of mice. Not only did the tailless parents always produce tailed offspring, but there was not even a reduction in the size of the tails.

DARWIN'S THEORY OF NATURAL SELECTION

Later Darwin put forth the theory of Natural Selection. This was based on certain facts :

(1) *Prolific race of reproduction in animals*. All animals, wanting their race to have the greatest chance of continuing, give rise to a number of offsprings. If all these offsprings survived, there would be no space on the earth for all. To give an example, take the tiny chinch bug. The tiny insect gives rise to 13 generations in a year and if all these survived, there would be 10 sextillion insects. Similar is the case of an oyster which produces 60,000,000 eggs, at a time. Vertebrates are comparatively low breeders. Yet, the world would very soon be overcrowded if all the offsprings of all the vertebrates survived. This gives rise to the struggle for existence. These are of three types—intraspecific struggle, interspecific struggle, and environmental struggle. *In intraspecific struggle*, the individuals of the same species compete with each other. For example, in forests, all trees produce millions of seeds. Of these only some reach the right type of soil. Of these, only some are able to germinate. Those that germinate grow, and their branches get intertwined cutting off sunlight and air and thus prove fatal to each other, and only the strongest are able to survive.

In interspecific struggle, animals of different species provide food for others in the chain, e.g., plankton (tiny surface organisms) provide food for small fish—eaten by bigger fishes and by larger whales. These are finally killed by men.

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* Mutilation —*Ed.*

Environmental struggle is against the environment. Thus, earthquakes, volcanoes, floods, etc., take heavy toll of life.

There are variations amongst animals, some having more useful variations and others having less useful variations. Thus, no two individuals are alike. With variations arises survival of the fittest, or the individuals with the best variations are naturally selected to carry on the race. These pass on the best variations so that only the best variations of the generations are passed on to the progeny giving rise to new species with better characters.

Yet though natural selection explains evolution in the best possible manner, there are certain facts that cannot be explained on the basis of natural selection. These are orthogenesis. For example, the antlers of the deer were useful for fighting, but they have been developed so far, that they have stopped being useful and are now harmful, as, when they get caught in bushes while the deer is being chased by an enemy, they endanger their life.

Over-specialization : For example, a butterfly, *Kallima* has its dorsal surface resembling a dead leaf so minutely that even an expert eye cannot pick it out from a pile of leaves.When it is chased by birds, it folds its wings and drops amongst dead leaves. A lesser degree of specialization would have been enough to save its life—so why this wastage of material in over-specialization ? Natural selection cannot explain.

Presence of vestigial organs : According to Natural Selection, the needful organs are developed further. But why are the vestigial organs not removed by the reversal of the theory as expected? Also, the process of passing on the characters is very slow and the beginning of the useful variations are so slow that they are not even perceived and not really useful till much later stages.

However, the evidences of fossils, etc., do uphold the theory and it cannot be quite discarded.

Yet, the most modern theory of evolution is, Hugo DeVries' theory of 'Discontinuous Variation,' or 'Sports'. While experimenting on certain flower, evening primrose, Hugo DeVries found that the plant, though usually bearing pink flowers, suddenly bore white flowers. The seeds from these flowers bred true, i.e., gave rise to plants bearing white flowers. He called this 'Sports' or 'Discontinuous Variations'. He said that organism suddenly underwent drastic changes giving rise to an entirely new species which had no connection with the past, i.e., there were no intermediates. This he attributed as being due to certrin cosmic rays. This had been proved, too, since another scientist managed to change the colour of the eyes of a certain fly *Drosophila*, by exposing it to X-rays and that acquired character was passed on.

Thus all these theories, having strong evidences in favour of them are not negligible and probably all work together giving rise to new species. Thus, we know from the steps of evolution that Man has evolved from the tail-less semi-erect ape which in turn evolved from the tailed monkey, and the line can be traced back to the beginning of life. Through these millions of years, nature has finally brought out man, and around us we see life—some in the primitive form like amoeba and sponges while others are well near the top of the ladder of evolution, like the apes and monkeys, with Man as the most intelligent animal at the top.

But has evolution stopped ? We cannot say—probably not. Then, after man—what ? We cannot say and we cannot know what trend nature will follow. But life after another million years will probably be nothing like our times, but will have evolved further, thus giving rise to even more superior being than man, who will probably say—'Man is our ancestor' much as we say 'We are the descendents of monkeys.'